# Monitoring Phosphorus, Nitrogen and Pathogenic Bacteria in the Cayuga Lake Watershed, 2004-Present

*Presentation to the Cayuga County Water Quality Management Agency*

*March 7, 2019*

*Cayuga County Natural Resources Center, 7413 County House Road, Auburn, NY*

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# What is the Value of Long-Term, Comprehensive Chemical Water Quality Data Sets for Watershed Management?

- Long-term, comprehensive, chemical water quality data sets are indispensable tools:
  - —For understanding shared water resources
  - —For managing shared water resources in a collective, equitable and effective manner
- <u>Definition of terms</u>
- "Long-term" means continuous, year after year
- "Comprehensive" means:
  - —Sampling repeatedly at multiple sites along a stream
  - —Sampling under a wide range of flow conditions
  - —Analyzing for phosphorus and nitrogen nutrients, pathogenic bacteria, sediment, and salt using NELAC-certified methods in order to produce regulatory-quality data
  - —Analyzing for other parameters as indicated by land use or pubic health concerns, e.g., metals, pesticides, microcystin toxin

# Long-term, Comprehensive Water Quality Data Sets Make It Possible To:

- Make generally accurate statements about water quality in monitored water bodies (as opposed to making sweeping assumptions about unmonitored water bodies)
- Identify sub-watersheds, and also catchment areas within sub-watersheds, that may be contributing disproportionately to pollutant loading
- Obtain nutrient loading estimates sufficient to focus watershed management efforts
- Assess public health risks due to pathogenic bacteria in streams and lakes
- Document long-term water quality trends and take corrective action, as appropriate
- Detect significant changes in monitored water quality parameters over time

# Long-Term, Comprehensive Water Quality Data Sets Are Extremely Rare

- Only a handful of high-profile watersheds are monitored extensively, e.g., the Chesapeake Bay watershed, Lake George, Lake Champlain


# Long-Term, Comprehensive Water Quality Data Sets Are Extremely Rare

- Monitoring is not particularly popular with agencies and universities, which tend to privilege:
  - —Short-term hypothesis-testing studies (considered scientifically exciting) over long-term monitoring (considered scientifically boring)
  - —Sample collection by paid staff and students over sample collection by trained volunteers (even though some volunteers have advanced degrees)
  - —Mathematical modeling, which is much easier than collecting actual monitoring data (though less accurate, according to EPA, and not necessarily cheaper)

# *Who we are and what we do*

## CSI's Mission:

CSI partners with community-based volunteer groups to better understand and protect local streams and lakes by collecting and disseminating scientifically credible, regulatory-quality data that inform long-term, sustainable management strategies.

NY State and EPA Certified Lab

Online Public Database

Volunteer Water Monitoring Partnerships

Chemical Monitoring Partnerships

Biological Monitoring Partnerships

Outreach and Education Initiatives

Small Nonprofit 501(c)3

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# Volunteer Monitoring Partnerships

**Synoptic Chemical Sampling** – Cayuga and Seneca Lake Watersheds

- Impacts from agriculture, urban development, point sources

**Red Flag Chemical Monitoring** – Upper Susquehanna Watershed

- Baseline and nutrient data collection on small streams

**Biological Monitoring (BMI)** – Any stream of local interest

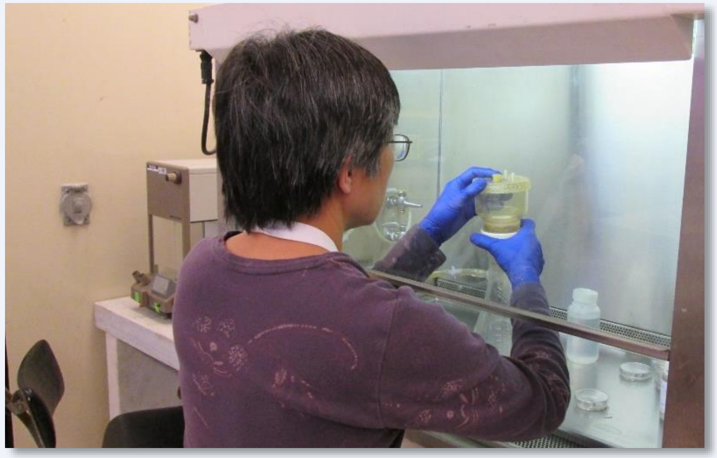
- Aquatic insect communities show long-term water quality

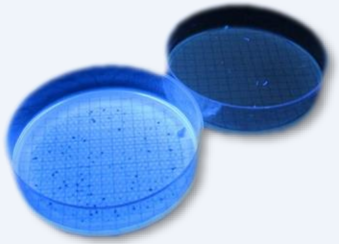
# Certified Lab

- Regulated by NYS Department of Health
  - Regulatory & Legal purposes
- Potable and Non-potable water
- Chemistry & Microbiology
- Full list of tests and fees online

Learn more about testing your drinking water at www.communityscience.org/certified-lab/

Michi tests for total coliform and E. coli bacteria

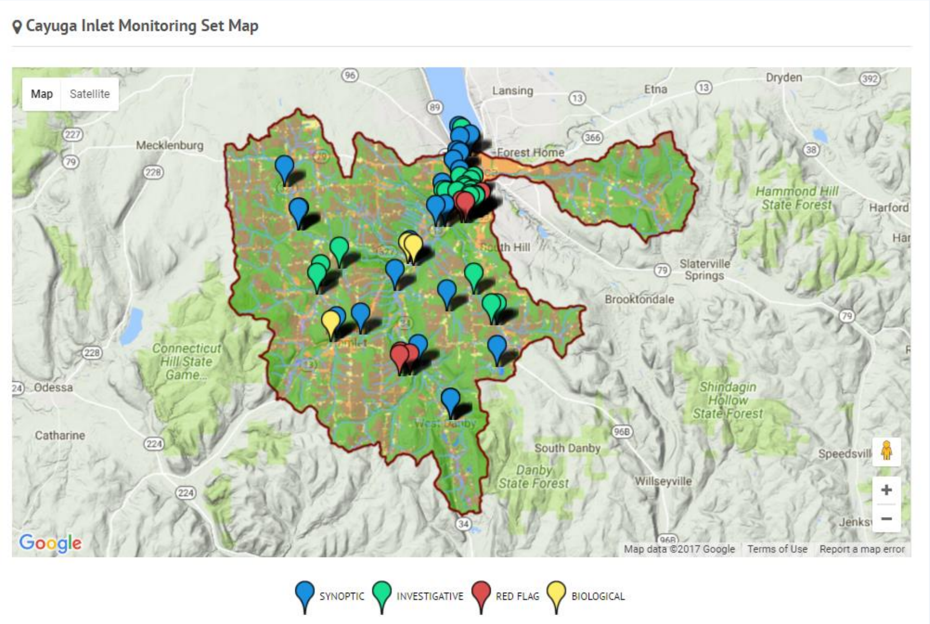


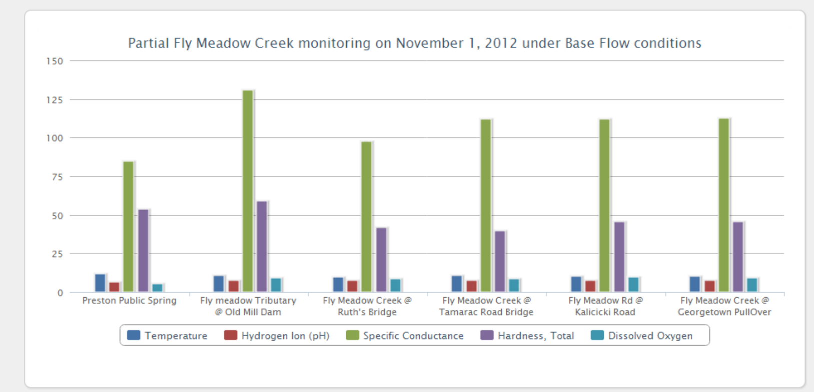


After the assay is complete bacteria colonies grow and are counted on plates

# Online Databases for Surface Water, Groundwater and (coming in 2019) BMI and HABs

- Raw stream monitoring data are archived in **public** online databases that may be searched and downloaded **free** of charge
- Goal is to disseminate scientifically credible results to the public, to local and regional stakeholders, and to government agencies at all levels in order to improve water resource understanding and management
- Streams and lakes database launched in 2006
- Groundwater database launched in 2014
- BMI and HABs databases in 2019

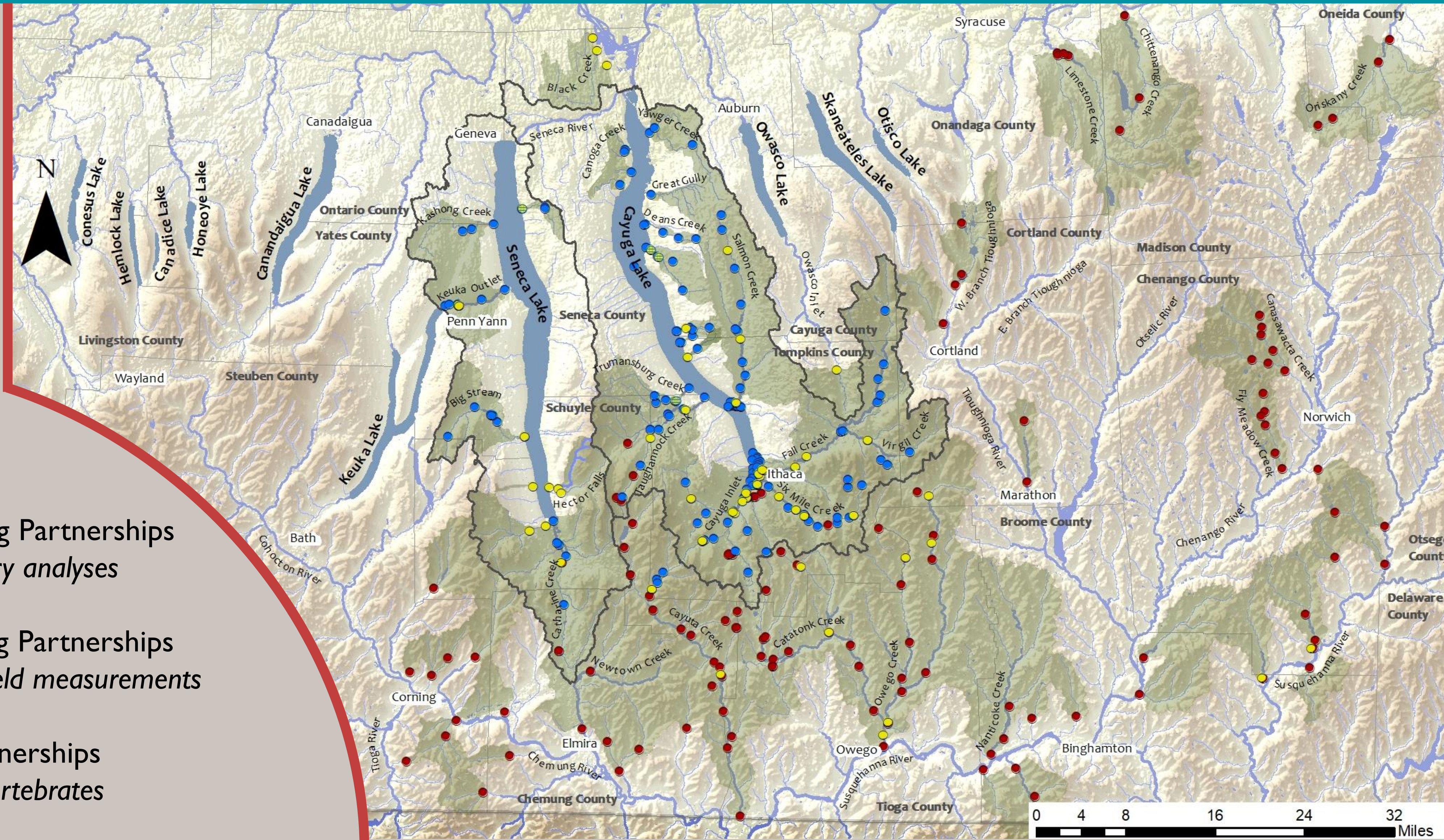


# Volunteer Water Monitoring Partnerships

## Three Volunteer Water Monitoring Programs

- Synoptic Sampling
- Red Flag Monitoring
- Biomonitoring




Synoptic Monitoring Partnerships
*Certified laboratory analyses*

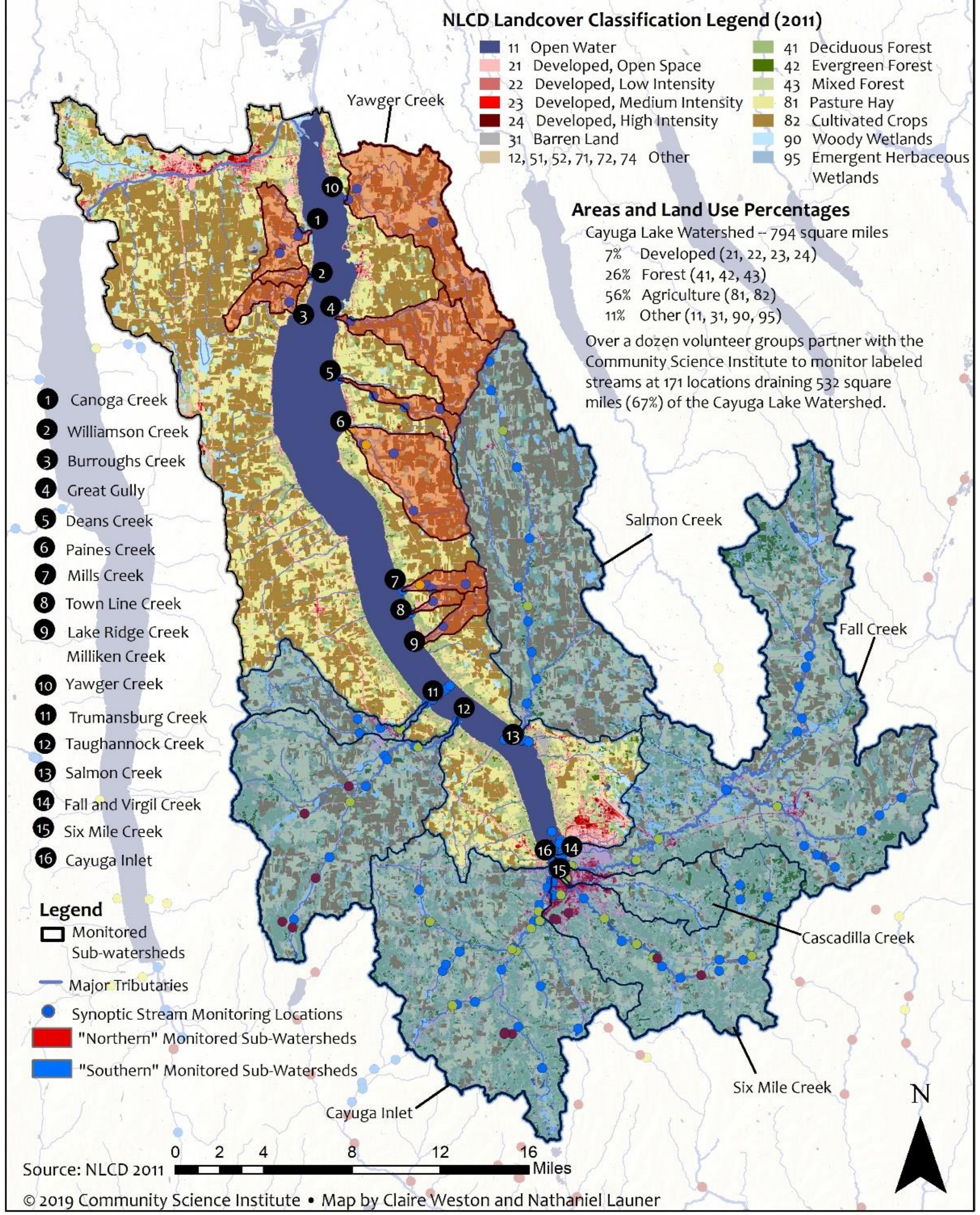
Red Flag Monitoring Partnerships
*Quality-assured field measurements*

Biomonitoring Partnerships
*Benthic macroinvertebrates*

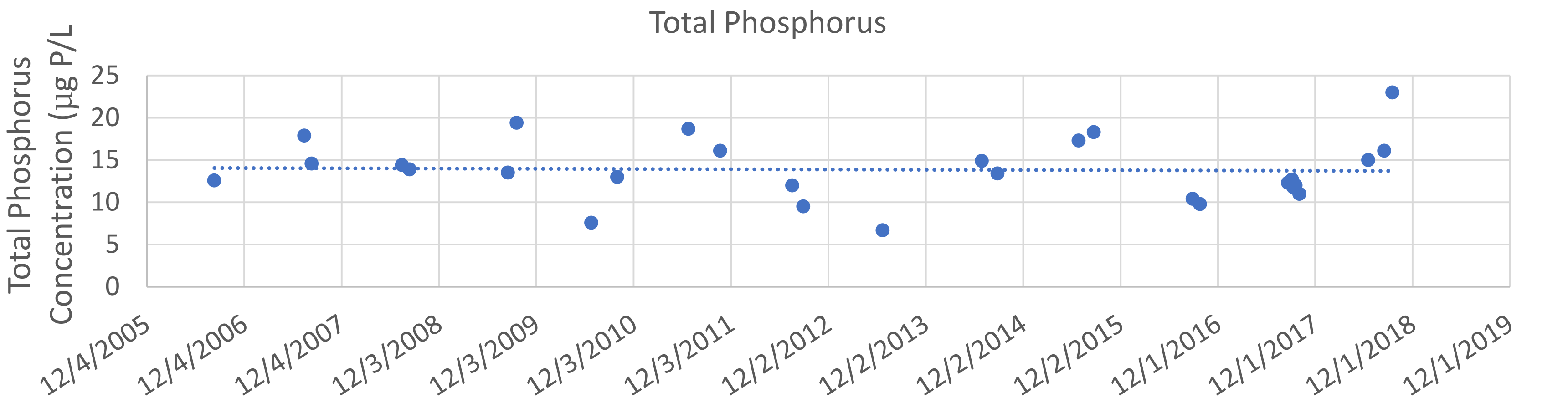
# Focus of this Talk is the Cayuga Lake Watershed Where CSI Has Most of its Volunteer Monitoring Partnerships

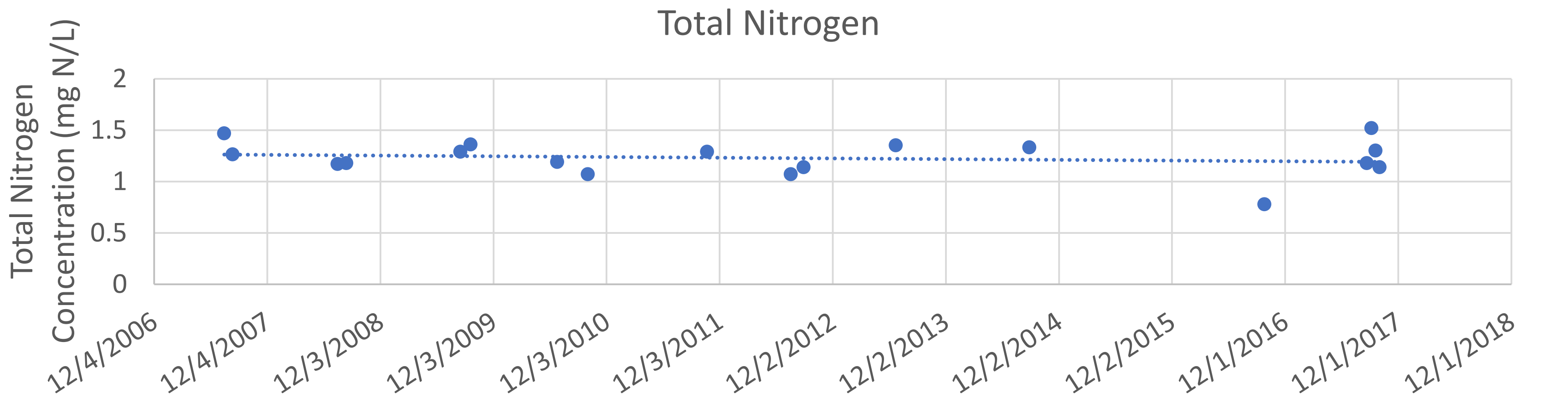
- Cayuga Lake is monitored at several locations 2 – 3 times a year in collaboration with the Floating Classroom and Tompkins County 4-H
- Fifteen (15) sub-watersheds are monitored 3-4 times a year at over 100 sampling locations in partnership with eleven (11) volunteer groups
- Samples are analyzed for SRP, TP, TN, E. coli, chloride (3x/year); and TSS, turbidity, specific conductance, total hardness, alkalinity, pH, dissolved oxygen (1x/year)
- CSI's Cayuga Lake watershed monitoring program is covered by a FL-LOWPA-approved QAPP

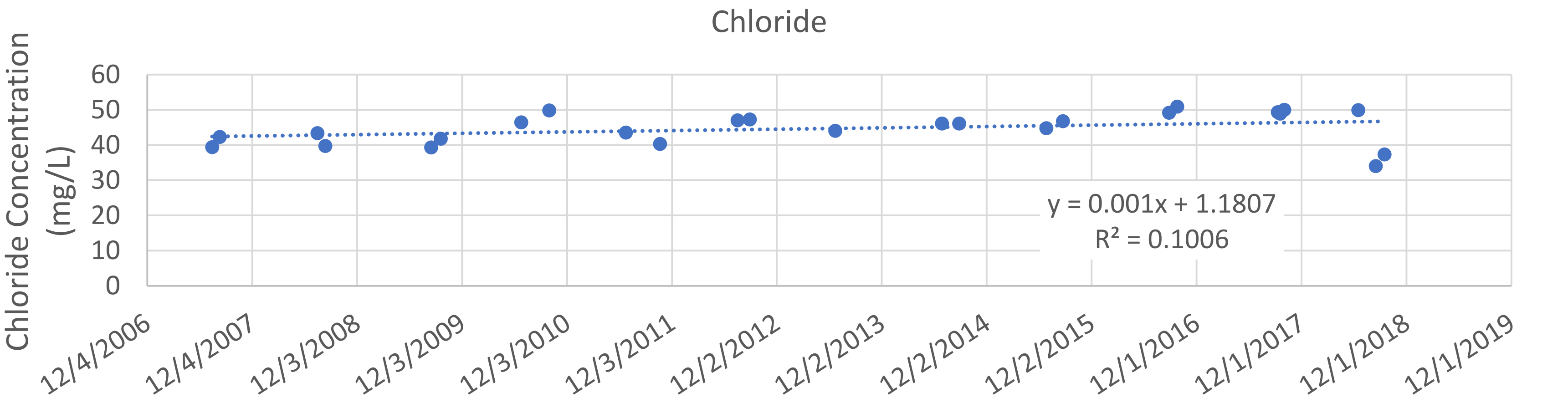
# Cayuga Lake Watershed Land Use and Monitored Sub-Watersheds



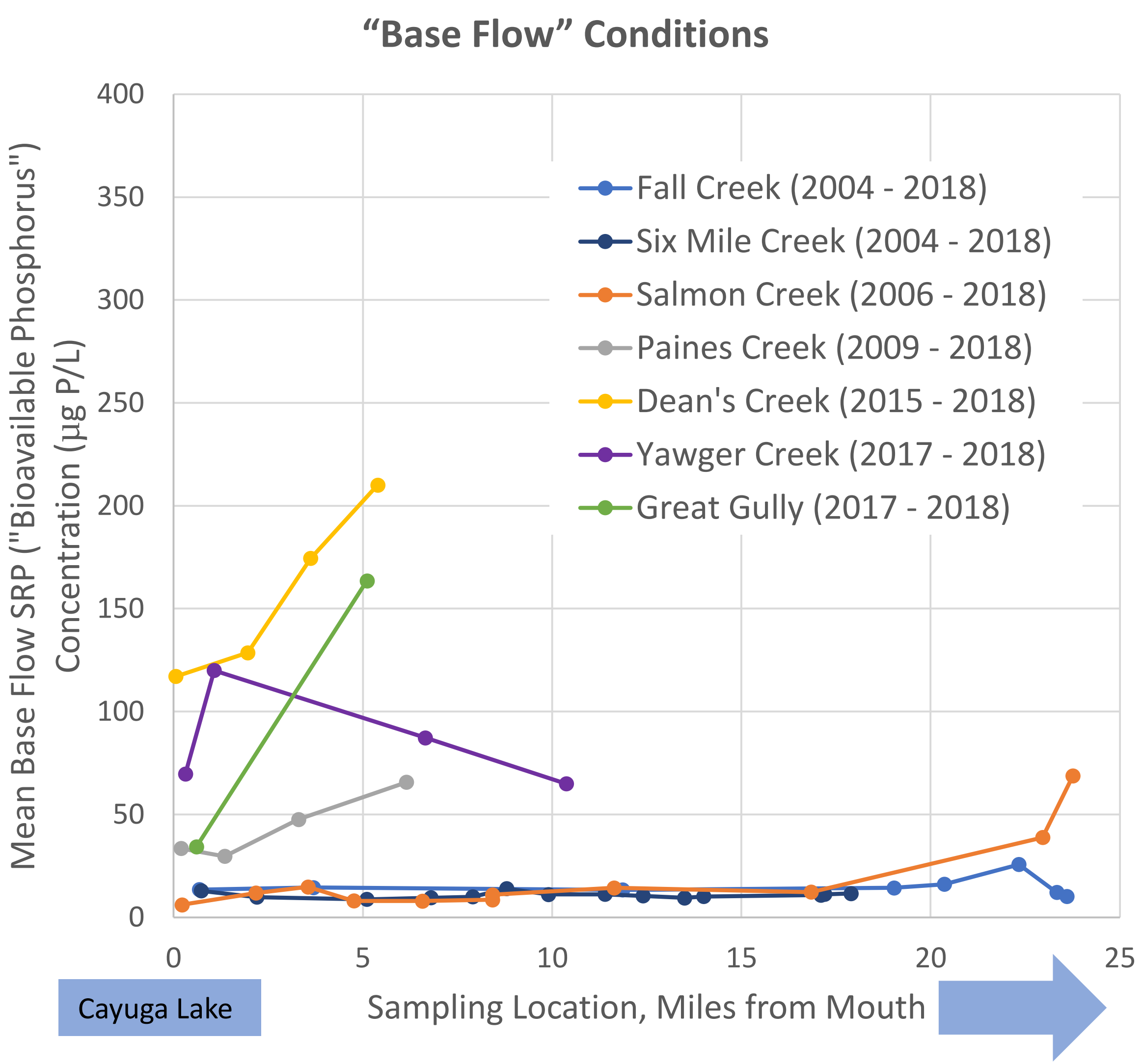
# Phosphorus and Nitrogen Levels Remain Constant in Southern Cayuga Lake, 2006-2018; Chloride Shows Upward Trend

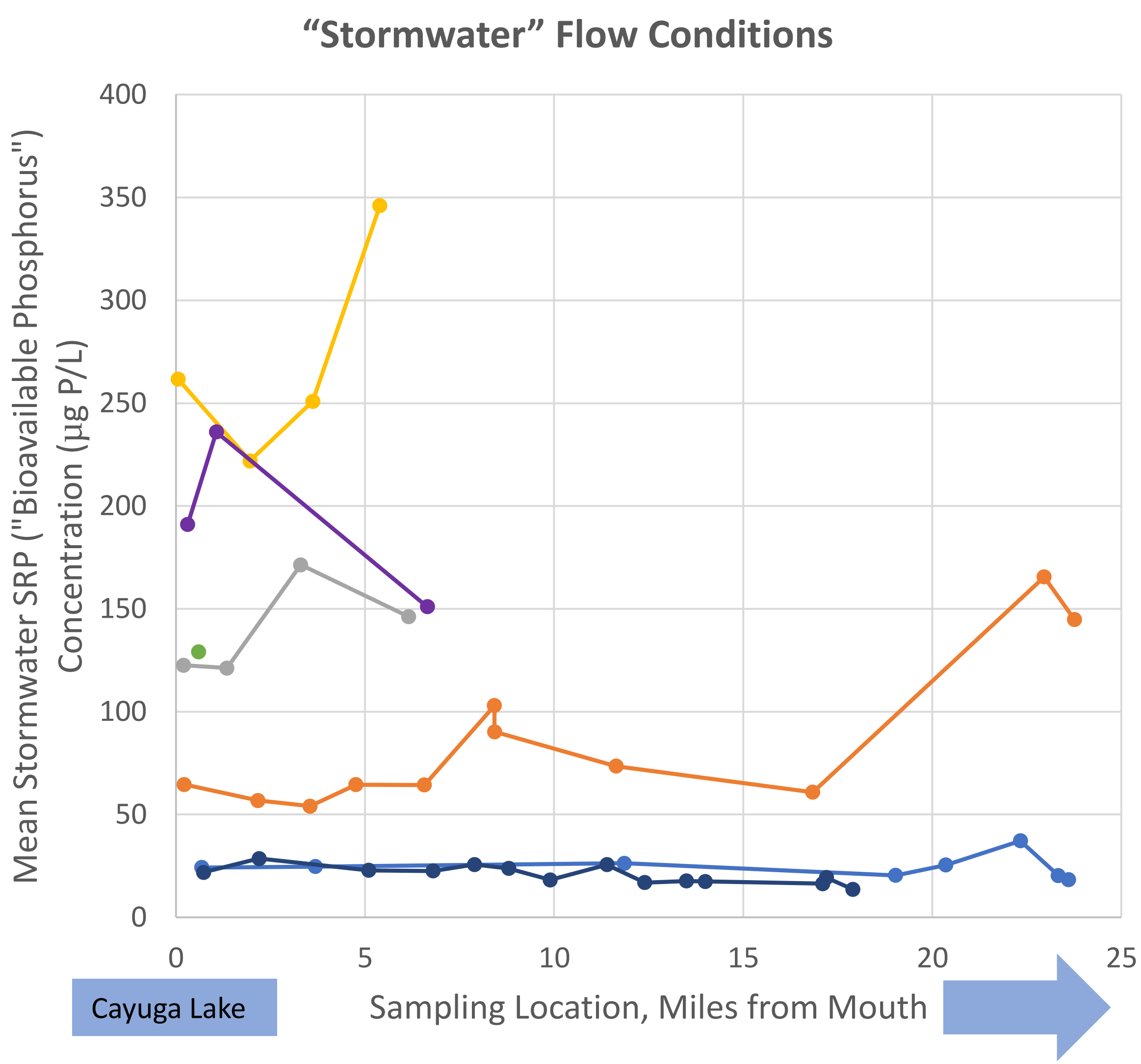



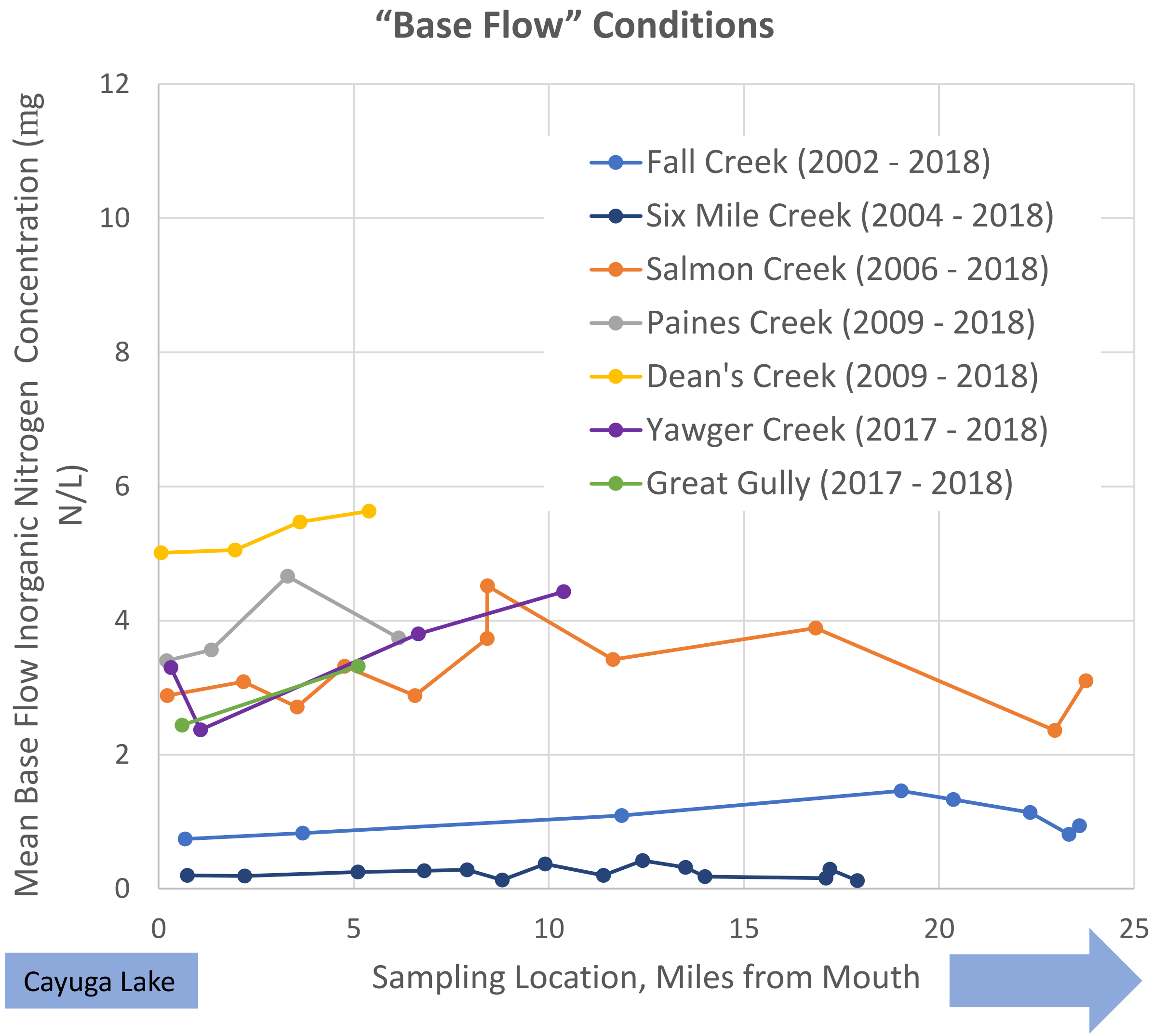



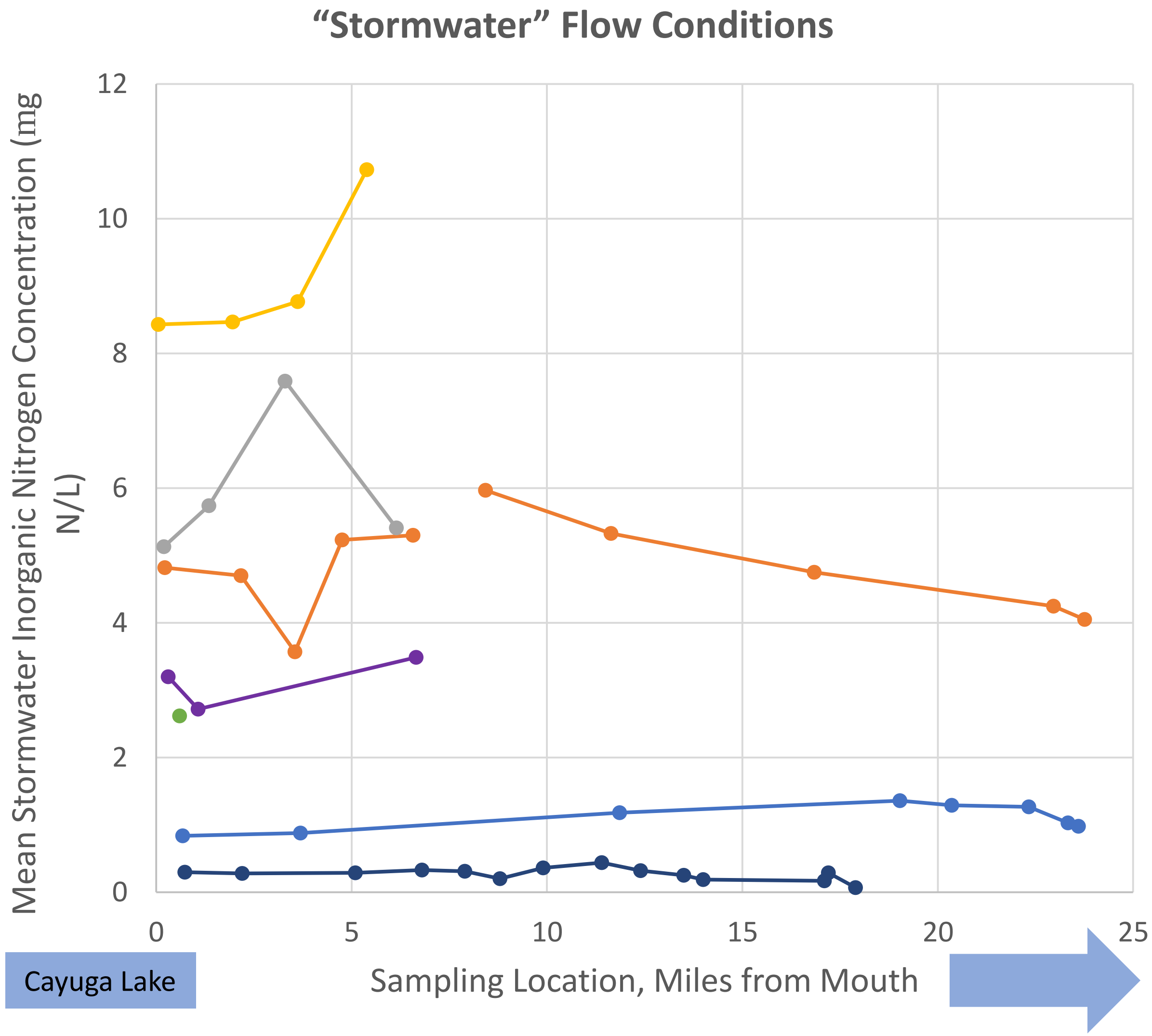
# Mean Concentrations of SRP ("Bioavailable Phosphorus") Throughout Selected Sub-watersheds of Cayuga Lake



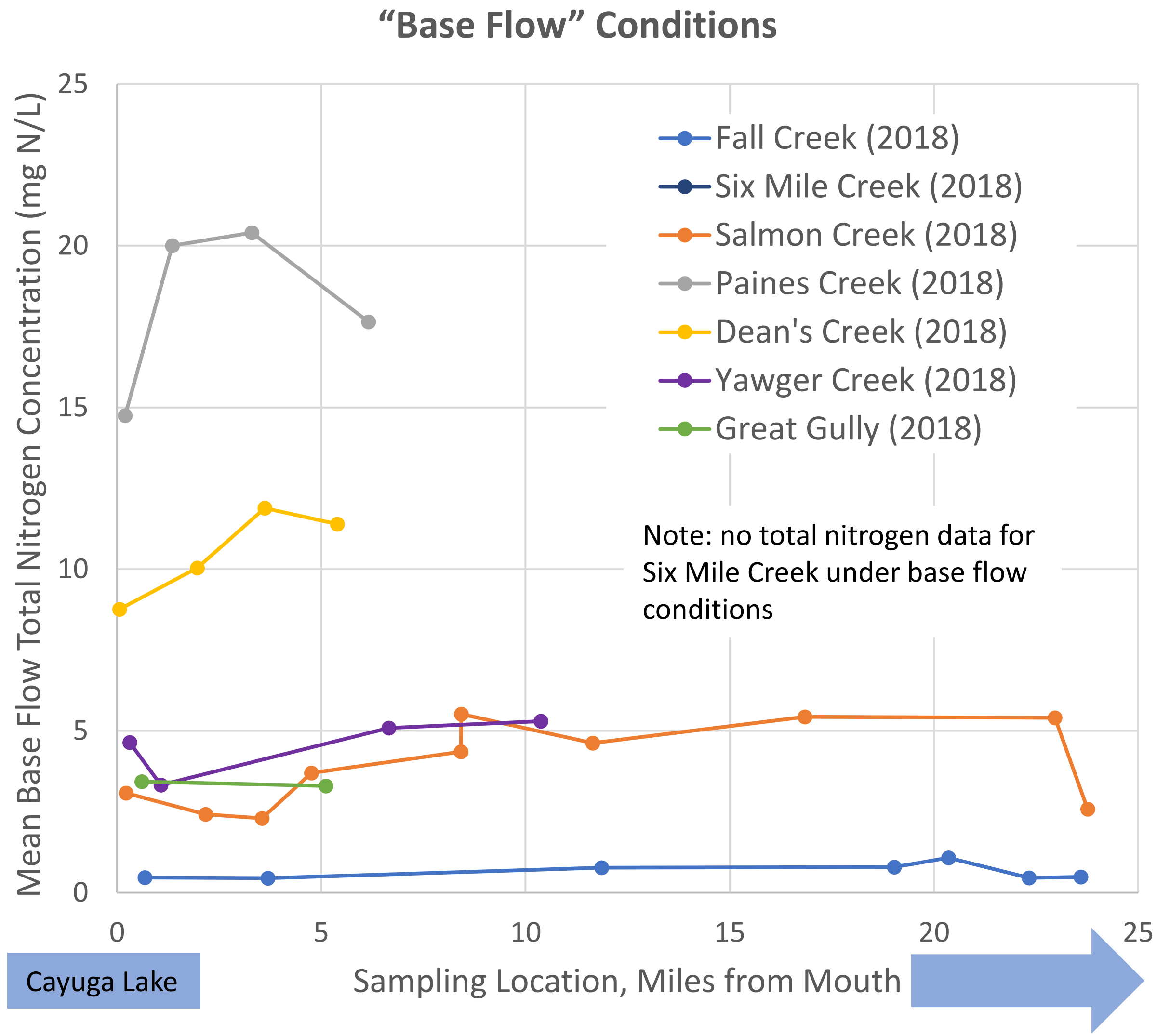



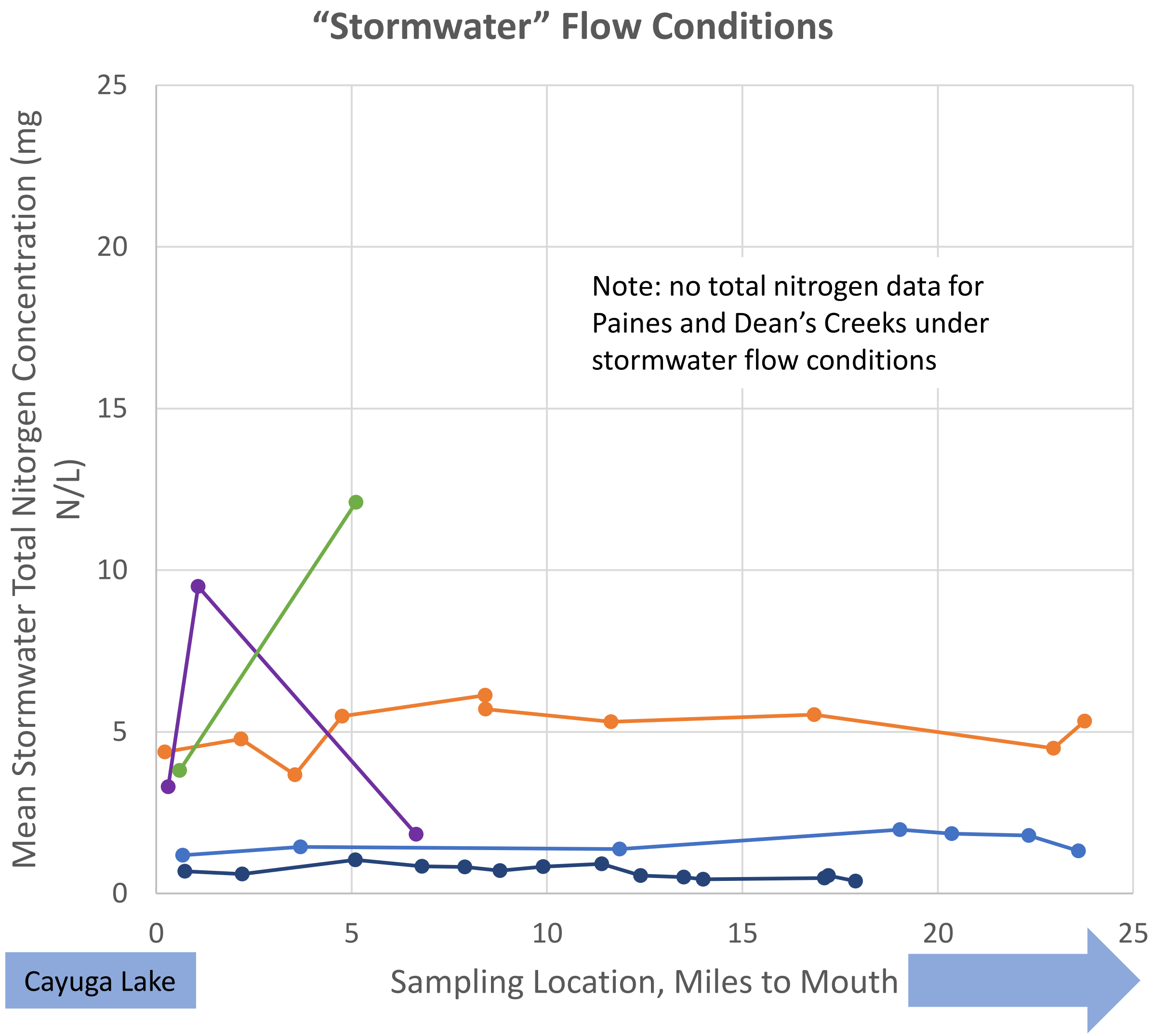
# Mean Concentrations of Inorganic Nitrogen Throughout Selected Sub-Watersheds of Cayuga lake



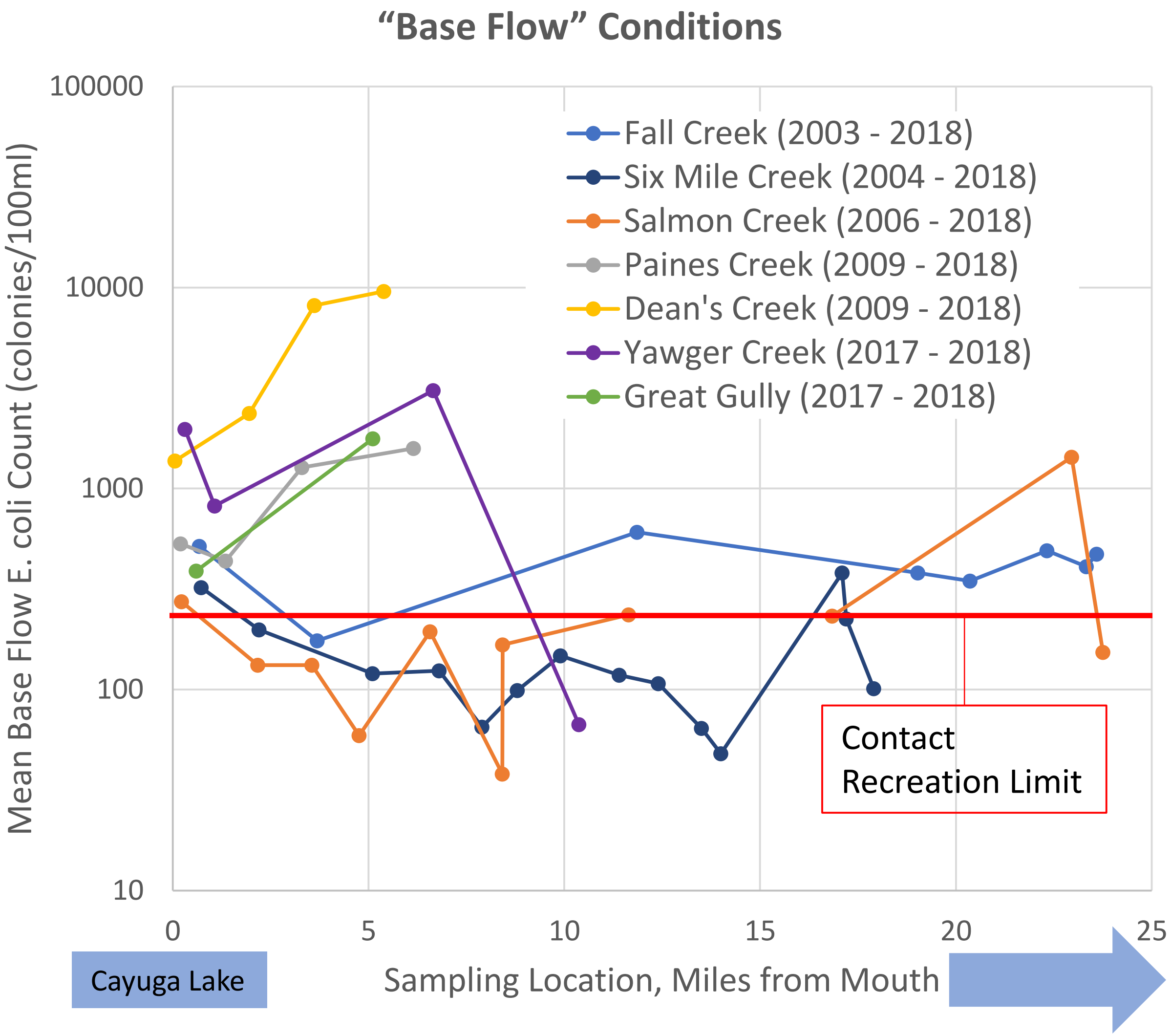



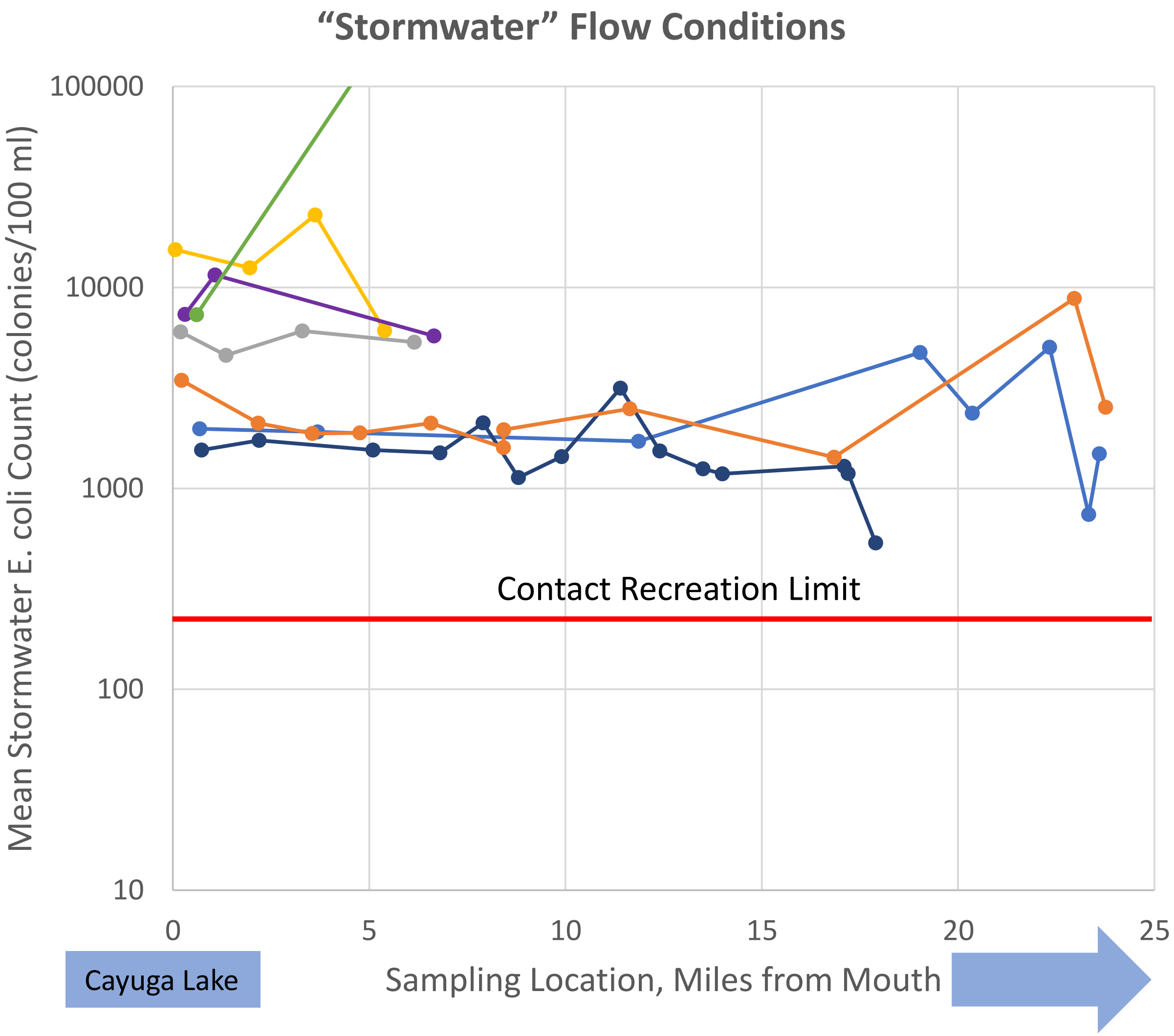
# Mean Concentrations of Total Nitrogen Throughout Selected Sub-Watersheds of Cayuga lake



# Mean Concentrations of E. coli Throughout Selected Sub-Watersheds of Cayuga Lake



# Nutrient Loading Estimates, “South” and “North”

- Phosphorus and nitrogen loading are estimated for southern Cayuga Lake tributaries based on Loadest software from USGS calibrated using: a) Nutrient concentration data from volunteer-CSI monitoring partnerships, and b) Flows from USGS gauging stations on Fall, Six Mile and Salmon Creeks. For ungauged streams, flows are estimated on the basis of drainage area ratios.
- For sub-watersheds north of the mouth of Salmon Creek, there is not yet enough nutrient concentration data to calibrate Loadest. Nevertheless, loads can be approximated if it is assumed that:
  1. Loads are proportional to sub-watershed area
  2. Loads are proportional to stormwater nutrient concentrations
  3. A known nutrient load can be used as a reference
- Using Fall Creek as a reference, SRP and Inorganic Nitrogen loads are approximated as follows:
  - SRP Load = Fall Creek SRP Load x (Area/129 $mi^2$) x (Stormwater SRP/25.06 ug P/L)
  - Inorganic Nitrogen Load = Fall Creek NOx Load x (Area/129 $mi^2$) x (Stormwater NOx/0.84 mg N/L)

# "Bioavailable Phosphorus" Loading to Cayuga Lake

| | Sub-Watershed (North to South) | Monitored Drainage Area ($mi^2$) | Estimated SRP Loading (tons/yr) |
|---|---|---|---|
| Northern Portion | Yawger Creek* | 24.9 | 6.39 |
| | Great Gully* | 15.6 | 2.70 |
| | Canoga Creek* | 5.83 | 1.22 |
| | Williamson Creek* | 1.40 | 0.27 |
| | Burroughs Creek* | 3.7 | 0.95 |
| | Deans Creek* | 3.2 | 1.12 |
| | Paines Creek* | 15.3 | 2.52 |
| | Mill Creek* | 1.4 | 0.24 |
| | Town Line Creek* | 1.7 | 0.20 |
| Southern Portion | Trumansburg Creek* | 13.07 | 0.76 |
| | Taughannock Creek* | 66.8 | 2.31 |
| | Salmon Creek* | 89.2 | 7.59 |
| | Fall Creek^ | 129.0 | 4.34 |
| | Cayuga Inlet^ | 158.0 | 3.14 |

^Calculated load, average 2011-2013
*Extrapolated from Fall Creek load

Northern Portion:

| Total Monitored Drainage Area | Total Estimated SRP Load |
|---|---|
| **73.03 $mi^2$** | **15.6 tons/yr** |

Southern Portion:

| Total Monitored Drainage Area | Total Estimated SRP Load |
|---|---|
| **456.07 $mi^2$** | **18.1 tons/yr** |

## Northern Watershed Loading Extrapolation

Northern Watershed Drainage Area = **332 $mi^2$**

$(332\ mi^2/73.03\ mi^2)$ x 15.62 tons/yr

=

**71.0 tons/yr**

# Inorganic Nitrogen Loading to Cayuga Lake

| Portion | Watershed (North to South) | Monitored Drainage Area ($mi^2$) | Estimated Inorganic Nitrogen Loading (tons/yr) |
|---|---|---|---|
| Northern Portion | Yawger Creek* | 24.9 | 131.48 |
| | Great Gully* | 15.6 | 67.44 |
| | Canoga Creek* | 5.83 | 43.00 |
| | Williamson Creek* | 1.40 | 7.46 |
| | Burroughs Creek* | 3.7 | 27.29 |
| | Deans Creek* | 3.2 | 44.51 |
| | Paines Creek* | 15.3 | 129.51 |
| | Mill Creek* | 1.4 | 22.22 |
| | Town Line Creek* | 1.7 | 20.31 |
| Southern Portion | Trumansburg Creek* | 13.07 | 34.07 |
| | Taughannock Creek* | 66.8 | 178.56 |
| | Salmon Creek* | 89.2 | 709.43 |
| | Fall Creek^ | 129.0 | 178.80 |
| | Cayuga Inlet^ | 158.0 | 70.60 |

^Calculated load, average 2011-2013
*Extrapolated from Fall Creek load

| Total Monitored Drainage Area | Total Estimated Inorganic Nitrogen Load |
|---|---|
| **73.03 $mi^2$** | **493.2 tons/yr** |

| Total Monitored Drainage Area | Total Estimated Inorganic Nitrogen Load |
|---|---|
| **456.07 $mi^2$** | **1,171.4 tons/yr** |

Northern Watershed Loading Extrapolation

Northern Watershed Drainage Area = **332 $mi^2$**

($332\ mi^2 / 73.03\ mi^2$) x 493.22 tons/yr

=

**2,237.7 tons/yr**

# Conclusions

- Nutrient concentrations are significantly higher, on average, in small "northern" streams than in large "southern" streams
- Assuming monitored streams are representative of unmonitored ones, the “northern” 43% of the watershed is estimated to load roughly 4x more “bioavailable phosphorus” and 2x more inorganic nitrogen to Cayuga Lake than the “southern” 57%. (<u>Note</u>: Organic nitrogen is not yet accounted for.)
- Six Mile Creek and Salmon Creek are the only monitored streams where E. coli counts average lower than the 235 colonies/100 ml threshold for safe swimming at most monitored locations under “base flow” conditions
- All monitored locations on all streams exceed the 235 colonies/100 ml threshold for safe swimming under stormwater conditions
- Total phosphorus and total nitrogen concentrations in southern Cayuga Lake have not changed over the past decade; chloride appears to have risen slightly, possibly driven by increases in southern tributary streams